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Exercise routine change is associated with prenatal depression scores during the COVID-19 pandemic among pregnant women across the United States
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Keywords:	Perinatal depression; coronavirus; pregnancy; mental health; physical activity
Abstract:	Background The COVID-19 pandemic has negatively affected physical and mental health worldwide. Pregnant women already exhibit an elevated risk for depression compared to the general public, a pattern expected to be exacerbated by the pandemic. Certain lifestyle factors, including moderate exercise, may help support mental health during pregnancy (e.g., by improving mood and increasing perceptions of control), but it is unclear how the pandemic may be impacting these associations across different locations. Here, we test whether: (i) altered exercise routines during the pandemic are associated with higher depression scores; and, (ii) women living in metro areas are more likely to report exercise changes compared to those in non-metro areas, potentially due to having limited space (both indoors and outdoors) for safe exercise. Methods This cross-sectional study uses data from the COVID-19 And Reproductive Effects (CARE) study, an online survey of pregnant women in the United States. Participants were recruited April-June 2020 (n = 1,862). Linear regression analyses assessed whether COVID-19-related exercise change was associated with depression score as measured by the Edinburgh Postnatal Depression Survey. Logistic regression analyses tested whether a participant's Rural-Urban Continuum Code classification of "metro" was linked with higher odds of reporting exercise changes compared to a "non-metro" classification. Results Women who reported exercise changes during the pandemic exhibited significantly higher depression scores compared to those reporting no changes. Moreover, individuals living in metro areas of all sizes were significantly more likely to report exercise changes compared to women living in non-metro areas. Conclusions These results suggest moderate exercise may represent a non-pharmaceutical tool for supporting maternal mental health. Providers should explicitly ask patients how the pandemic has impacted their exercise routines and consider this a risk factor for depression. Efforts should be made to recommend exercises that are tailored to individual living conditions and physical health.
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Exercise routine change is associated with prenatal depression scores during the COVID-19 pandemic among pregnant women across the United States

Running title: COVID-19-related exercise change and depression by location

Keywords: Perinatal depression; coronavirus; pregnancy; mental health; physical activity

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Abstract

Background: The COVID-19 pandemic has negatively affected physical and mental health worldwide. Pregnant women already exhibit an elevated risk for depression compared to the general public, a pattern expected to be exacerbated by the pandemic. Certain lifestyle factors, including moderate exercise, may help support mental health during pregnancy (e.g., by improving mood and increasing perceptions of control), but it is unclear how the pandemic may be impacting these associations across different locations. Here, we test whether: (i) altered exercise routines during the pandemic are associated with higher depression scores; and, (ii) women living in metro areas are more likely to report exercise changes compared to those in non-metro areas, potentially due to having limited space (both indoors and outdoors) for safe exercise.

Methods: This cross-sectional study uses data from the COVID-19 And Reproductive Effects (CARE) study, an online survey of pregnant women in the United States. Participants were recruited April-June 2020 (n = 1,862). Linear regression analyses assessed whether COVID-19-related exercise change was associated with depression score as measured by the Edinburgh Postnatal Depression Survey. Logistic regression analyses tested whether a participant's Rural-Urban Continuum Code classification of "metro" was linked with higher odds of reporting exercise changes compared to a "non-metro" classification.

Results: Women who reported exercise changes during the pandemic exhibited significantly higher depression scores compared to those reporting no changes. Moreover, individuals living in metro areas of all sizes were significantly more likely to report exercise changes compared to women living in non-metro areas.

Conclusions: These results suggest moderate exercise may represent a non-pharmaceutical tool for supporting maternal mental health. Providers should explicitly ask patients how the pandemic has

24   impacted their exercise routines and consider this a risk factor for depression. Efforts should be made to

25   recommend exercises that are tailored to individual living conditions and physical health. (300/300

26   words)

27

28 Author summary

29   The COVID-19 pandemic has negatively impacted the well-being of people across the U.S. and

30   has been linked with elevated depression rates. However, certain groups may be disproportionally

31   impacted, including pregnant women. Given the relatively high rates of depressive symptomology

32   evident among pregnant women prior to the pandemic, supporting the maternal mental health during

33   these challenging times is especially important. However, fetal exposure to psychotropic medications

34   taken by the mother limits their utility, necessitating the use of non-pharmaceutical treatments, such as

35   moderate exercise, to improve mental health outcomes. Yet, regular exercise routines have likely been

36   affected by the pandemic – especially for those living in densely-populated areas where space to

37   exercise safely is limited – but these associations are not well tested among pregnant women. Here,

38   using data from an online survey of 1,862 women living in the U.S., we find that women who reported

39   exercise changes during the pandemic exhibited higher depression scores compared to those able to

40   maintain their exercise routine. Moreover, individuals living in metro areas were more likely to report

41   exercise changes compared to women living in non-metro areas. These findings suggest an association

42   exists between ability to maintain an exercise routine during the pandemic and maternal depression

43   risk. (200/200 words)

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2

Introduction

The COVID-19 pandemic has impacted the health and livelihoods of people around the world.

However, certain countries have been hit harder than others, with the United States exhibiting the

highest prevalence and mortality estimates globally. As of September 19, 2020, 6,749,092 people living

in the U.S. are estimated to have been infected with the novel coronavirus SARS-CoV-2, while 198,940

are thought to have died from the resulting disease COVID-19 (1). Within the U.S., certain populations

appear to be at higher risk for negative COVID-19 disease outcomes, including pregnant women.

Although the specific effects of COVID-19 on pregnancy are still being tested, some researchers argue

pregnant women are generally at higher risk for viral respiratory illness (2). Moreover, other studies

indicate that COVID-19 may be associated with an elevated risk for placental injury, pre-eclampsia,

preterm birth, and low birth weight (3–5). These recent findings led the CDC to add pregnancy as a risk

factor for severe COVID-19 outcomes on June 25, 2020 (6).

In addition to potentially being at an elevated risk for poor COVID-19 health outcomes, the CDC

cautions that pregnant women may feel increased stress or anxiety during the pandemic (6). The

physical distancing and "stay at home" orders implemented by many local governments to slow the

spread of SARS-CoV-2 are thought to increase feelings of anxiety and isolation, especially among already

vulnerable populations (7). Pregnancy-associated physiological changes have been clearly linked with

increased depression risk, such that 1 in 8 women in the U.S. have been estimated to experience

postpartum depression symptoms (8). These depression-related symptoms include fatigue, changes to

appetite or sleep, crying more often than usual, withdrawing from loved ones or the baby, feelings of

anger, sorrow, hopelessness, worthlessness, or restlessness, and suicidal ideology (8).

Recent evidence suggests that maternal depression symptomatology has become even more

common during the COVID-19 pandemic. Specifically, one study comparing mental health among

70   pregnant women/new mothers before and after the onset of the pandemic found that rates of clinical

71   depression and moderate to high anxiety significantly increased with the onset of the pandemic (7).

72   These changes appear to be directly linked with the disruptions to daily routines, social isolation, and

73   fears of developing COVID-19, highlighting the need for increased maternal health screening and

74   treatment (7). Other factors, including increased COVID-19-related financial stress or changes to working

75   plans in pregnancy have also been associated with increased depression (9,10). Given the probable

76   exposure of offspring to any psychotropic medications taken by the mother during pregnancy or

77   breastfeeding (11), the identification of non-pharmaceutical treatments to reduce maternal depression

78   is of great interest.

79   One such alternative treatment may be maintaining a regular exercise routine throughout

80   pregnancy and the postpartum period, which has been shown to both prevent and help treat depression

81   symptoms among women able to safely engage in moderate to vigorous physical activity (11–15).

82   Regular exercise has been linked with several beneficial effects, including improved body satisfaction

83   (16), reduced physical discomfort (17), feelings of physical control despite somatic changes linked with

84   pregnancy (18,19), and improved mood through the release of endorphins and neurotransmitters

85   (18,20). It has therefore been recommended by the American College of Obstetricians and Gynecologists

86   that pregnant women without medical contraindications engage in at least 150 minutes of moderate-

87   intensity aerobic activity every week, divided into 30 minutes intervals most days of the week (21). Yet,

88   many pregnant women do not exercise at the recommended levels, due in large part to fatigue, time

89   constraints (e.g., work and childcare), and pregnancy-related physical limitations (e.g., back pain,

90   swelling, and joint pain) (22,23). Differences are also apparent by location, with pregnant women living

91   in urban areas exhibiting significantly higher levels of moderate physical activity compared to those

92   living in rural areas, likely because of increased access to fitness centers (24,25).

93   Regardless of location, the benefits of exercise during pregnancy appears to be especially

94   relevant during the COVID-19 pandemic, with women who reported at least 150 min of moderate

95   intensity exercise exhibiting significantly lower scores for both anxiety and depression than those who

96   did not (7). Yet the direct effects of the pandemic on exercise regimens among pregnant women

97   remains poorly tested. Given the effects of shelter in place orders, it seems likely that many women's

98   exercise routines will be disrupted by the pandemic, especially in metro areas (e.g., due to fitness

99   centers and parks closing or a fear of viral exposure while exercising outside in a densely populated

100   area). Conversely, women in less densely populated areas may feel safer going outside to engage in

101   physical activities. However, the relationship between pandemic-related changes in exercise routines

102   and depression risk has yet to be directly tested, and it is unclear how geographic location may impact

103   this association.

104   We therefore use data drawn from the COVID-19 and Reproductive Effects (CARE) study to test

105   the following two hypotheses among pregnant women living in the U.S.:

106   1) Participants who report changes in their exercise routines during the COVID-19 pandemic will

107   demonstrate significantly higher depression scores compared to women who are able to

108   maintain their exercise routine during the pandemic.

109   2) Compared to individuals who live in non-metro areas, participants living in metro areas (of all

110   sizes) will be significantly more likely to report COVID-19-related changes in their exercise

111   routines.

112

Materials and methods

Study design

115   The COVID-19 And Reproductive Effects (CARE) study was posted on social media platforms

116   (Facebook, Twitter) and distributed via email to contacts working in maternity care and public health.

117   Pregnant women over the age of 18 and living in the U.S. were invited to participate in a short survey

118   assessing how the COVID-19 pandemic was impacting their medical care and birth plans. The data

119   presented here were collected between April 16 – June 16, 2020. This study received ethical approval

120   from Dartmouth College (STUDY00032045).

121   The survey was administered in REDCap, which automatically captures survey responses. Only

122   women who met the inclusion criteria (i.e., living in the U.S., over 18 years of age, and currently

123   pregnant) were eligible to participate in the survey. The survey completion rate (i.e., the percentage of

124   those who consented to take the survey and actually went through to the end of the questionnaire) was

125   80%. During the study period, there were 1,862 surveys collected that included responses for all study

126   variables. Data on depression symptomatology, exercise routines, and geographic location were

127   collected, along with various covariates known to influence exercise patterns and depression risk.

128   *Depression scores*: Depression symptoms were screened using the Edinburgh Postnatal

129   Depression Survey (EPDS), resulting in a participant score ranging from 0 (minimum) to 30 (maximum)

130   (26). Depression scores were analyzed continuously.

131   *Exercise routine changes:* Participants were asked "has your exercise routine changed at all since

132   the COVID-19 pandemic began?" Participants responded yes or no. Additionally, participants were asked

133   the number of days per week (on average) they engaged in moderate exercise for at least 30 minutes.

134   *Geographic location:* Participants self-reported their zip codes. This information was used to

135   generate a Rural-Urban Continuum Code (RUCC) for each respondent (27). The RUCC is based on the

136   county located at the zip code center point, with each participant receiving a code on a 1-9 scale. For

137   this analysis, the codes were collapsed as follows: 1) metro county of 1 million people or more, 2) metro

138   county of 250,000 to 1 million people, 3) metro county of less than 250,000 people, and 4) all non-metro

139 counties. In addition, participants reported whether or not they lived in an area where they were

140 currently required to shelter in place (i.e., not leave home, except for essential activities).

141 *Age:* Participants self-reported their age in years.

142 *Current gestational week:* Participants indicated their current gestational week.

143 *Race/ethnicity*: Race/ethnicity were self-reported and measured according to the Office of

144 Management and Budget Standards (28). Native Hawaiian/Pacific Islander participants were re-classified

145 as "Other" due to a small sample size (n = 3).

146 *Household income:* Participants indicated their household income from the following options:

147 Less than $10,000 (1); $10,000 – $19,999 (2); $20,000 – $34,999 (3); $35,000 – $49,999 (4); $50,000 –

148 $74,999 (5); $75,000 – $99,999 (6); $100,000+ (7). A composite household income variable was created

149 for analysis: < $49,999, $50,000 – $99,999, and $100,000+.

150 *Education*: Participants selected their highest completed education from the following options:

151 Some high school, no diploma (1); High school graduate, diploma or the equivalent (for example: GED)

152 (2); Some college credit, no degree (3); Trade/technical/vocational training (4); Associate degree (5);

153 Bachelor's degree (6); Master's degree (7); Professional degree (8); Doctorate degree (9). A composite

154 education variable was created for analysis: less than a bachelor's degree, a bachelor's degree, or a

155 degree beyond a bachelor's degree.

156 *Financial stress:* Participants were asked to rate whether they agreed or disagreed (Likert

157 question; 5 options ranging from strongly disagree to strongly agree) with the statement "I am worried

158 about my financial situation due to the COVID-19 crisis." Participants who stated that they agreed or

159 strongly agreed with the statement were classified as having experienced COVID-19-related financial

160 stress.

161 *Risk status:* Women were asked whether their pregnancy was classified as "high-risk." In

162 addition, participants aged 35 or older were classified as "high-risk".

7

Statistical analysis

Data analyses were conducted using Stata 14. All continuous variables exhibited normal distributions, with skewness values within approximately ±0.5 and kurtosis values within approximately ±3. Multicollinearity was not detected between any variables; all VIF values were in an acceptable range of 1.01-1.65. Study descriptive statistics were calculated, and regression analyses were conducted to test the study hypotheses. Results were considered statistically significant at a p-value of less than 0.05.

Hypothesis 1: Linear regression analyses assessed whether exercise routine change during the COVID-19 pandemic was significantly associated with participant depression score.

Hypothesis 2: Logistic regression analyses tested whether a participant RUCC classification of "metro" was linked with significantly higher odds of reporting an altered exercise routine during the pandemic compared to a classification of "non-metro".

All regression models adjusted for maternal age, education, income, financial stress, week of pregnancy at time of survey, race/ethnicity, and "high-risk" pregnancy.

Results

Sample characteristics and descriptive statistics

The study sample was spread out across all 50 states, including one participant in the U.S. territory of Puerto Rico (**Figure 1**). A clear majority of the sample (92.3%) indicated they lived in a location that required individuals to shelter in place (i.e., stay home, except for essential activities) at the time they completed the survey. Most women in the sample were physically active, with 56.4% of respondents reporting they engaged in moderate exercise for at least 30 minutes three or more days per week (versus the 17.9% of women who reported they were inactive).

185   Sample descriptive statistics are presented in **Table 1**. Mean participant age was 31 years old

186   and the mean number of weeks pregnant was 26. Most respondents were white (87% of the sample),

187   educated (77% had at least a bachelor's degree), lived in a metro area of 1 million or more people (61%

188   of the sample), and were relatively high-income (55% reported an annual household income of $100,000

189   or more). Still, approximately 43% of participants reported that they worried about their financial

190   situation due to the COVID-19 pandemic. Most participants (65%) did not indicate a high-risk pregnancy.

191   Additionally, the majority of participants (60%) reported that their exercise routine had changed during

192   the COVID-19 pandemic. Finally, participants varied in depression scores as measured by the EPDS scale,

193   ranging from the minimum score of 0 all the way to the maximum score of 30; the mean EPDS score was

194   10.6.

195   **Figure 1. Study participant locations across the United States. The number of participants in each zip**
196   **code is summarized across United States counties and displayed as percentage of county population**
197   (29)**, with darker colors representing areas where participants make up a higher percentage of the**
198   **county population (see legend). Data are presented for the sample used in the present analyses (n =**
199   **1,862). State and county spatial data courtesy Census.gov.**
200
201   **Table 1. Descriptive statistics of model variables. Sample means (with standard deviation and range)**
202   **or frequency (percent) of model variables, for 1,862 participants included in the analyses.**
203

Variable	Mean (SD; range)
Age (years)	31.3 (4.30; 18-47)
Weeks pregnant at time of survey	26.0 (8.73; 0-41)
Edinburgh Postnatal Depression Survey (EPDS) score	10.6 (5.34; 0-30)
	Frequency (%)
Race/ethnicity:	
White	1,618 (86.9%)
Hispanic, Latino, or Spanish origin	112 (6.02%)
Black or African American	24 (1.29%)
Asian	60 (3.22%)
American Indian or Alaskan Native	12 (0.64%)

Other	36 (1.93%)
Household income:	
< $49,999	222 (11.9%)
$50,000 - $99,999	610 (32.8%)
$100,000+	1,030 (55.3%)
Education level:	
Less than a bachelor's degree	427 (22.9%)
Bachelor's degree	647 (34.8%)
Degree beyond a bachelor's degree	788 (42.3%)
Financial stress:	
Not worried	1,067 (57.3%)
Worried	795 (42.7%)
High-risk pregnancy:	
No	1,212 (65.1%)
Yes	650 (34.9%)
Exercise routine changed:	
No	736 (39.5%)
Yes	1,126 (60.5%)
RUCC code:	
Metro, 1 million+	1,133 (60.8%)
Metro, 250,000 – 999,999	394 (21.2%)
Metro, < 250,000	140 (7.52%)
Non-metro	195 (10.5%)

204
205

Hypothesis 1

207   Linear regression analyses were carried out to assess whether exercise routine change during

208   the pandemic was significantly associated with depression score, measured using the EPDS (**Table 2**).

209 Participants who were older (B = -0.071, 95%CI: -0.140-(-0.001), p = 0.046), reported a higher household

210 income (compared to < $49,999) of $50,000 - $99,999 (B = -0.944, 95%CI: -1.77-(-0.112), p = 0.026) or

211 $100,000+ (B = -1.34, 95%CI: -2.22-(-0.470), p = 0.003), and were more highly educated (compared to

212 less than a bachelor's degree) with either a bachelor's degree (B = -0.873, 95%CI: -1.56-(-0.189), p =

213 0.012) or a degree beyond a bachelor's degree (B = -1.13, 95%CI: -1.83-(-0.426), p = 0.002) exhibited

214 significantly lower depression scores.

215   Conversely, participants who were Hispanic, Latino, or Spanish in origin (B = 1.29, 95%CI: 0.306-

216 2.27, p = 0.010) or who reported experiencing COVID-19-related financial stress (B = 2.26, 95%CI: 1.78-

217 2.75, p < 0.001) displayed significantly higher depression scores. Finally, as hypothesized, women who

218 reported their exercise routine had changed during the pandemic demonstrated significantly higher

219 depression scores (B = 0.917, 95%CI: 0.434-1.40, p < 0.001).

220

221 **Table 2. Linear regression model assessing associations between reported exercise changes during the**
222 **COVID-19 pandemic and depression, as measured by a continuous Edinburgh Postnatal Depression**
223 **Survey (EPDS) score. Beta coefficients are provided with standard errors, 95% confidence intervals,**
224 **and p-values for each variable included in the model.**
225

Variable	B coefficient (SE, 95% CI)	p-value
Intercept	**12.45 (1.07, 10.36-14.5)**	**<0.001**
Age (years)	**-0.071 (0.035, -0.140-(-0.001))**	**0.046**
Weeks pregnant at time of survey	0.019 (0.014, -0.007-0.046)	0.156
Race/ethnicity:		
White	reference	
Hispanic, Latino, or Spanish origin	**1.29 (0.501, 0.306-2.27)**	**0.010**
Black or African American	0.039 (1.05, -2.02-2.10)	0.970
Asian	-1.01 (0.673, -2.33-0.311)	0.134
American Indian or Alaskan Native	-0.350 (1.48, -3.25-2.55)	0.813
Other	-0.456 (0.859, -2.14-1.23)	0.596

Household income:		
< $49,999	reference	
$50,000 - $99,999	**-0.944 (0.424, -1.77-(-0.112))**	**0.026**
$100,000+	**-1.34 (0.446, -2.22-(-0.470))**	**0.003**
Education level:		
Less than a bachelor's degree	reference	
Bachelor's degree	**-0.873 (0.349, -1.56-(-0.189))**	**0.012**
Degree beyond a bachelor's degree	**-1.13 (0.359, -1.83-(-0.426))**	**0.002**
Financial stress (no vs. yes)	**2.26 (0.246, 1.78-2.75)**	**<0.001**
High-risk pregnancy (no vs. yes)	0.561 (0.291, -0.009-1.13)	0.054
Exercise routine changed (no vs. yes)	**0.917 (0.246, 0.434-1.40)**	**<0.001**

226
227

Hypothesis 2

Logistic regression analyses were carried out to assess whether participant geographic location

(i.e., non-metro vs. metro), as assessed by RUCC, was associated with significantly higher odds of

reporting an altered exercise routine during the COVID-19 pandemic (**Table 3**). Participants who were

farther along in their pregnancy had significantly lower odds of reporting changes to their exercise (OR =

0.986, 95%CI: 0.975-0.997, p = 0.010). Meanwhile, participants with a higher household income

(compared to < $49,999) of $50,000 - $99,999 (OR = 1.56, 95%CI: 1.11-2.18, p = 0.010) or $100,000+ (OR

= 1.58, 95%CI: 1.11-2.26, p = 0.012) and were more highly educated (compared to less than a bachelor's

degree) with either a bachelor's degree (OR = 1.54, 95%CI: 1.17-2.03, p = 0.002) or a degree beyond a

bachelor's degree (OR = 2.04, 95%CI: 1.53-2.71, p < 0.001) exhibited significantly higher odds of

reporting exercise routine changes. Participants who reported experiencing pandemic-related financial

stress (OR = 1.26, 95%CI: 1.03-1.54, p = 0.024) also displayed significantly higher odds of reporting

exercise routine changes.

241   Finally, compared to participants living in a non-metro area, those living in a metro area of 1

242 million or more people (1.96, 95%CI: 1.42-2.71, p < 0.001), a metro area of 250,000 – 999,999 people

243 (OR = 1.72, 95%CI: 1.21-2.46, p = 0.003), or a metro area of < 250,000 people (OR = 2.03, 95%CI: 1.29-

244 3.20, p = 0.002) demonstrated significantly higher odds of reporting exercise routine changes, as

245 hypothesized (**Figure 2**).

246

247 **Table 3. Logistic regression model assessing associations between participant Rural-Urban Continuum**
248 **Code (RUCC) and reported exercise change. Odds ratios are provided with standard errors, 95%**
249 **confidence intervals, and p-values for each variable included in the model.**
250

Variable	OR (SE, 95% CI)	p-value
Intercept	0.429 (0.196, 0.176-1.05)	0.063
Age (years)	1.00 (0.015, 0.974-1.03)	0.874
Weeks pregnant at time of survey	**0.986 (0.006, 0.975-0.997)**	**0.010**
Race/ethnicity:		
White	reference	
Hispanic, Latino, or Spanish origin	1.39 (0.295, 0.913-2.10)	0.125
Black or African American	1.04 (0.462, 0.433-2.48)	0.936
Asian	1.52 (0.467, 0.833-2.78)	0.173
American Indian or Alaskan Native	1.27 (0.772, 0.388-4.18)	0.691
Other	0.935 (0.329, 0.469-1.86)	0.848
Household income:		
< $49,999	reference	
$50,000 - $99,999	**1.56 (0.267, 1.11-2.18)**	**0.010**
$100,000+	**1.58 (0.289, 1.11-2.26)**	**0.012**
Education level:		
Less than a bachelor's degree	reference	
Bachelor's degree	**1.54 (0.216, 1.17-2.03)**	**0.002**
Degree beyond a bachelor's degree	**2.04 (0.297, 1.53-2.71)**	**<0.001**

Financial stress (no vs. yes)	**1.26 (0.129, 1.03-1.54)**	**0.024**
High-risk pregnancy (no vs. yes)	1.10 (0.133, 0.870-1.40)	0.420
RUCC:		
Non-metro	reference	
Metro, 1 million+	**1.96 (0.323, 1.42-2.71)**	**<0.001**
Metro, 250,000 – 999,999	**1.72 (0.313, 1.21-2.46)**	**0.003**
Metro, < 250,000	**2.03 (0.470, 1.29-3.20)**	**0.002**

251
252
253 **Figure 2. Percentage of study participants reporting change in exercise routine by United States**
254 **county for (A) metro counties, and (B) non-metro counties. Map colors represent the proportion of**
255 **participants in the sample reporting exercise routine changes during the pandemic within a given**
256 **county (see legend), ranging from blue (a low percentage of sample participants reported exercise**
257 **changes) to red (a high percentage of sample participants reported exercise routine changes). Metro**
258 **counties are displayed in gray-scale according to the USDA Rural-Urban Continuum Codes (RUCC),**
259 **while non-metro counties are displayed in white** (27)**. State and county spatial data courtesy**
260 **Census.gov.**
261
262

Discussion

264   The study findings support both hypotheses. Women who reported exercise changes during the

265 COVID-19 pandemic exhibited significantly higher depression scores compared to those who reported

266 no changes. Moreover, individuals living in metro areas of all sizes were significantly more likely to

267 report exercise changes compared to women living in non-metro areas, potentially because women

268 living in more rural areas felt safer venturing outside for walks or other forms of physical activity given

269 the lower population density and less perceived risk of viral exposure. Although cross-sectional and

270 preliminary in nature, these results align with existing studies demonstrating the beneficial effects of

271 exercise during pregnancy (11–15), suggesting moderate exercise may serve as a tool for supporting

272 mental health during pregnancy.

273   Further, the association documented here suggests one possible mechanism by which the

274   ongoing COVID-19 pandemic may impair maternal mental health. Business closures and stay at home

275   orders resulting from the pandemic may directly inhibit one's ability to engage in physical activity. The

276   majority of study participants (92.3%) indicated they were currently experiencing shelter in place orders,

277   likely leading to disruptions in daily routines, including ability to engage in normal exercise activities.

278   This idea is generally supported by preliminary analyses from the sample suggesting that a high

279   percentage of participants (47.4%) explicitly reported exercising less following the onset of the

280   pandemic, while many fewer respondents reported they were exercising more (9.12%). This difference

281   suggests that exercise changes during the pandemic have generally resulted in less physical activity. This

282   may be linked with gym, recreation center, and park closures that disrupt normal exercise routines,

283   especially in urban areas where there is limited green space available for outdoor physical activity.

284   The disruption of exercise routines may have several negative effects contributing to elevated

285   depression symptomatology, including decreased body satisfaction, increased physical discomfort,

286   perceptions of not being in control (of both physical changes associated with pregnancy and everyday

287   activities), as well as poor mood (16–20). Thus, maternal depression risk—already a concern among

288   pregnant women prior to the COVID-19 pandemic—may be exacerbated during the pandemic partly

289   because of disruptions to daily routines, including typical exercise regimens. The effects of altered

290   exercise routines on maternal health may be especially relevant in the CARE study sample. These data

291   were collected from women living in the U.S., the country hardest hit by the COVID-19 pandemic thus

292   far (1). The prolonged nature of the lockdowns and current uptick of infections in many parts of the

293   country will likely continue to disrupt normal routines, including ability to exercise, for the foreseeable

294   future. Consequently, the association between depression score and changes in exercise routine

295   documented here suggest that maternal depression screenings should account for the impact of COVID-

296   19 on physical activity levels, in addition to other effects of the pandemic on maternal well-being.

297   Additionally, providers should consider how ability to engage in physical activity during the

298   pandemic may influence maternal mental health, particularly among women living in urban areas.

299   Providers and/or fitness specialists could work with pregnant women and new mothers to find simple

300   routines (e.g., exercises that can be completed safely from home without specialized equipment and

301   which do not require much open space) to encourage physical activity during the pandemic across all

302   demographics and living conditions. Indeed, it has been suggested that household chores, walks,

303   gardening, and online fitness classes may be possible alternatives to support maternal physical and

304   mental health (7).

305   However, efforts must be made to recommend exercises tailored to each individual's living

306   conditions and physical health, as the negative effects of changed exercise routines are not likely to be

307   experienced equally across all sociodemographic groups. Specifically, higher-income women with access

308   to more resources may find it easier to adopt alternative forms of exercise as the pandemic continues

309   (e.g., purchase home gym equipment or exercise videos), allowing them stay physically active even if

310   they live in urban areas where they cannot easily access a gym or exercise outside. Conversely, lower-

311   income communities located in densely populated areas without infrastructure (e.g., green space and

312   sidewalks) to support safe outdoor activities during COVID-19 may be more substantially impacted by

313   pandemic-related public facility closures and shelter in place orders. However, this remains to be

314   directly tested using a more diverse sample.

315

316 Limitations

317   It should be noted that despite the strengths of these analyses (e.g., large sample size and

318   participants from across the country), several important study limitations exist. First, this study is cross-

319   sectional, making it difficult to establish causality. For instance, it is not possible to definitively establish

320   whether the significant relationship observed between exercise routine change during the pandemic

321   and depression score is due to disrupted exercise routines leading to later depression or to maternal

322   depression leading to decreased motivation to exercise. The relationship between physical activity and

323   depression appears to be bidirectional in nature, with exercise protecting against depression but

324   baseline depression also subsequently decreasing physical activity levels (30). Longitudinal data

325   collection is needed to establish these causal relationships.

326   In addition, due to the use of convenience sampling, these data are not representative of the

327   U.S. population as a whole; white, educated, wealthy women are overrepresented in the present sample

328   (31). Additional work is needed to determine whether the associations observed here are also evident

329   across a more representative, diverse sample of the U.S. population. Finally, quantitative data on pre-

330   pandemic exercise patterns were not collected, making it difficult to establish whether the patterns

331   documented here partly reflect pre-existing physical activity differences. For example, previous work

332   indicates that pregnant women living in urban areas exhibit higher levels of moderate exercise

333   compared to those living in rural areas (24,25); these women may therefore be less likely to report

334   exercise changes as they were not regularly exercising prior to the pandemic. Still, this pattern does not

335   detract from the finding that urban women appear to be exercising less during the pandemic, which

336   may negatively impact their physical and mental well-being.

337

Conclusions

339   The COVID-19 pandemic has far-ranging effects on both mental and physical health. Certain

340   segments of the population may be especially impacted by the pandemic; including pregnant women,

341   who already suffer from an elevated depression risk compared to the general public (8). The findings

342   presented here support previous work and suggest an association exists between ability to maintain an

343   exercise routine during pregnancy and depression risk. Providers should explicitly ask patients how the

344   pandemic has impacted their exercise routines and consider this a risk factor for depression. Moreover,

345   efforts should be made to recommend exercises that are tailored to individual living conditions (e.g.,

346   whether they can safely exercise outdoors) and physical health.

347   Specifically, the findings presented here indicate that women living in metro areas were

348   significantly more likely to report exercise routine changes during the pandemic than women living in

349   non-metro areas. This may signify an opportunity for interventions—especially in urban areas—which

350   rely on simple exercises that can safely be performed at home without specialized equipment (e.g.,

351   squats, lunges, side-lying leg lifts, etc.). Importantly, exercise recommendations may be most effective if

352   communicated by providers who understand the personal health and space limitations of each

353   individual patient. Exercise represents a potential non-pharmaceutical tool to support both mental and

354   physical health among pregnant women, both during and after the pandemic.

355

Acknowledgements

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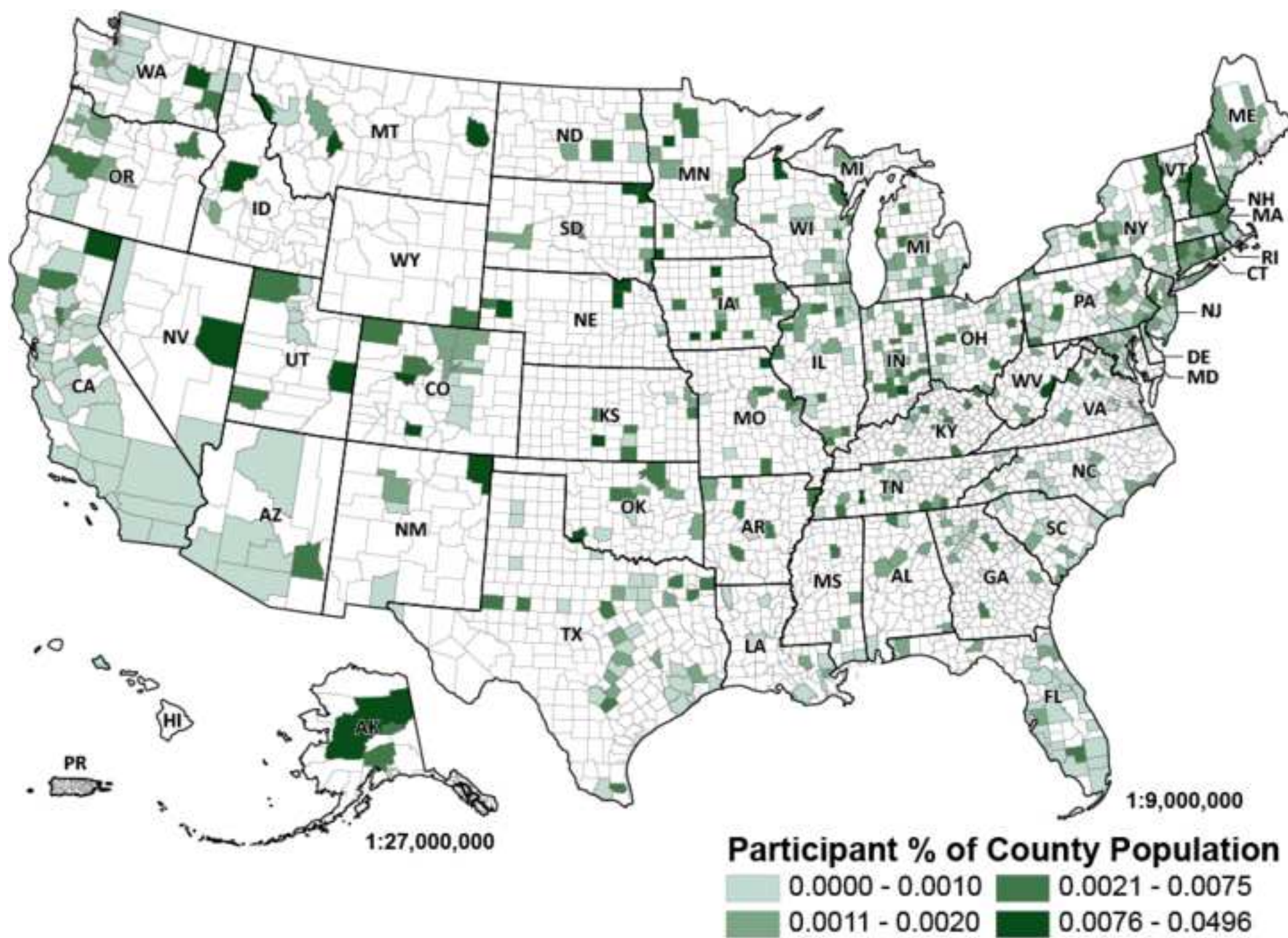
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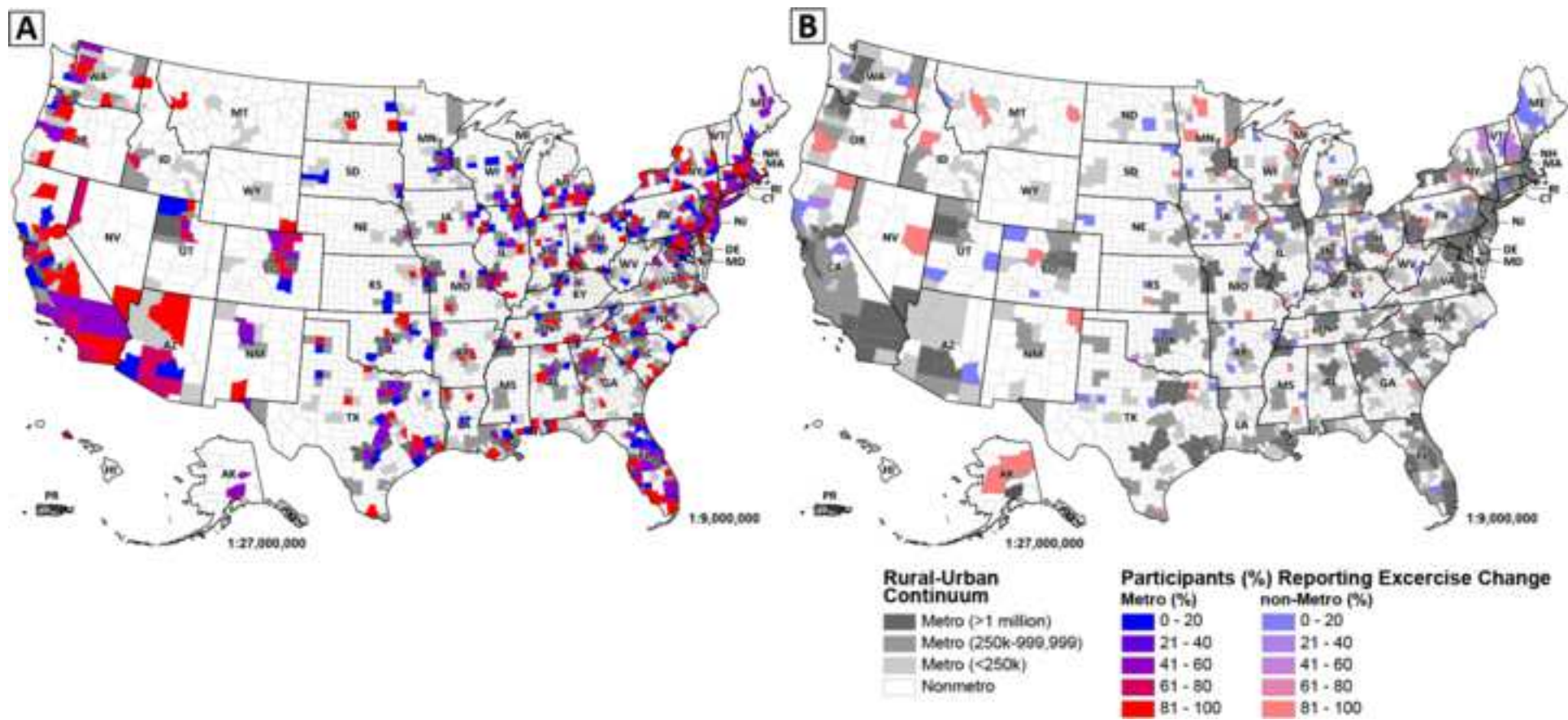438   codes.aspx

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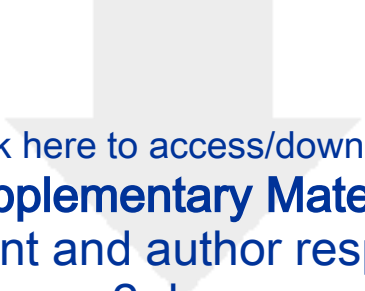
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450 Supporting information

451   **S1 Checklist.** STROBE Checklist.

Participant % of County Population
- 0.0000 - 0.0010
- 0.0011 - 0.0020
- 0.0021 - 0.0075
- 0.0076 - 0.0496

1:9,000,000

1:27,000,000

Rural-Urban Continuum
- Metro (>1 million)
- Metro (250k-999,999)
- Metro (<250k)
- Nonmetro

Participants (%) Reporting Excercise Change

Metro (%)	non-Metro (%)
0 - 20	0 - 20
21 - 40	21 - 40
41 - 60	41 - 60
61 - 80	61 - 80
81 - 100	81 - 100

Click here to access/download
Supporting Information
Gildner
STROBE_checklist_v4_combined_PlosMedicine.docx